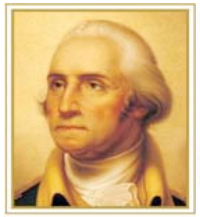

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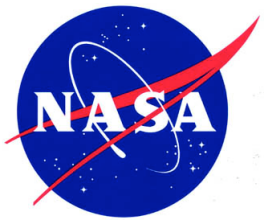

An Application of Wavelet Based Dimension Reduction to AIRS Data

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Outline

- Introduction to Dimension Reduction
- AIRS Instrument and Data Processing
- Wavelet Dimension Reduction
- Experiments and Results
- Concluding Remarks
- References

Introduction to Dimension Reduction

- Hyperspectral sensors provide more richer information than traditional multi-spectral sensors
- Conventional processing needs a generous amount of resources to process Hyperspectral data
- Results in “curse of dimensionality”
- Perform dimension reduction as pre-processing
- Dimension Reduction Techniques
  - Principal Component Analysis (PCA)
  - Wavelet Based Dimension Reduction

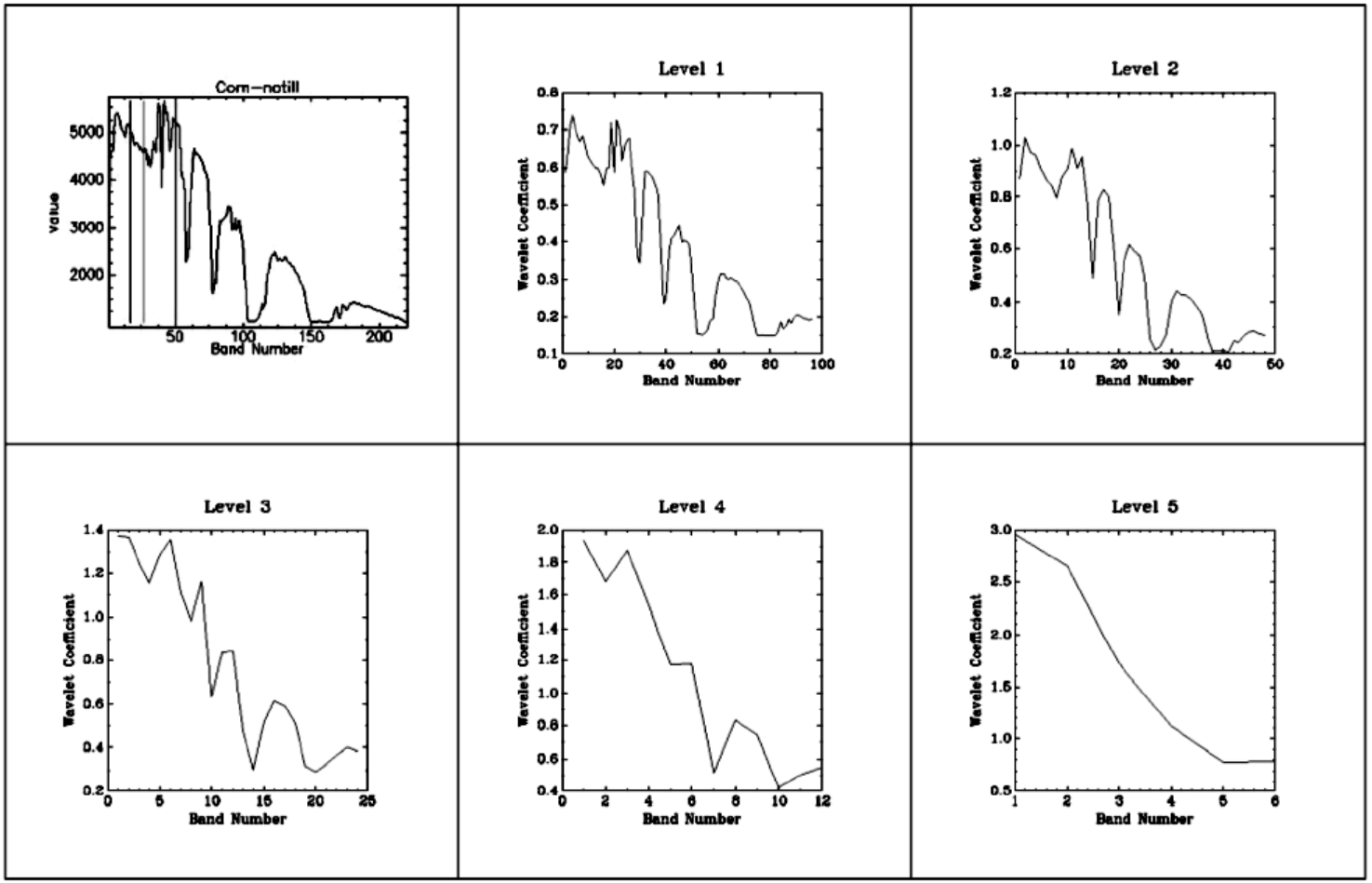
AIRS Data

- The Atmospheric Infrared Sounder (AIRS) instrument is used to create Earth's three-dimensional maps of temperature, humidity, and clouds
- Used to predict more accurate weather forecasts
- AIRS Data consists of:
  - An infrared sounder with 2378 spectral channels
  - An imaging module of 4-channel in visible/near-infrared
  - A microwave temperature sounder Advanced Microwave Sounding Unit-A (AMSU-A) with 15 microwave channels
  - A microwave humidity sounder with 4 microwave humidity channels
- Currently scientists use 281 reduced channels which are chosen "appropriately"
- Automatic data reduction algorithms are required to retain information contained in all channels

Wavelet Based Dimension Reduction

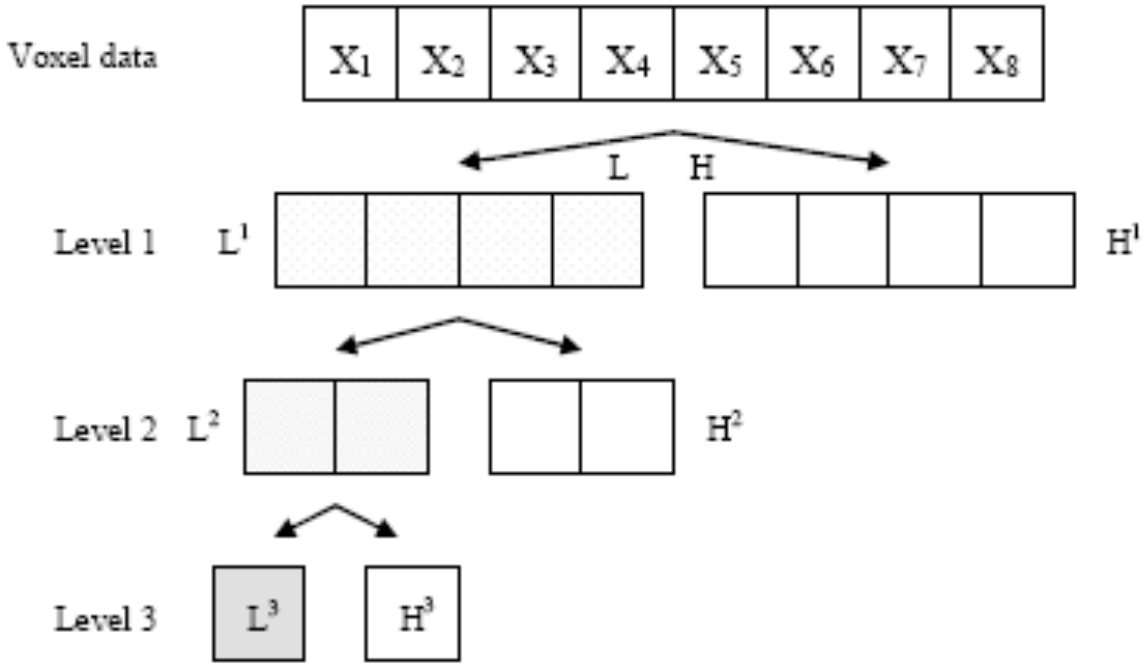
- Dimension reduction involves filtering of redundant information
- In wavelet-based method:
  - Apply a discrete, one-dimensional wavelet transform in the spectral domain and at each pixel
  - This transform decomposes the signature into:
    - Linear combination of original spectral band
    - Weighted combinations of the original spectral bands
- Similar classification results were produced when PCA based dimension reduction was applied over AVIRIS hyperspectal dataset

Wavelet Based Dimension Reduction over AVRIS Data



Example of the Corn Spectral Signature
And Different Levels of Wavelet Decomposition

Wavelet Decomposition

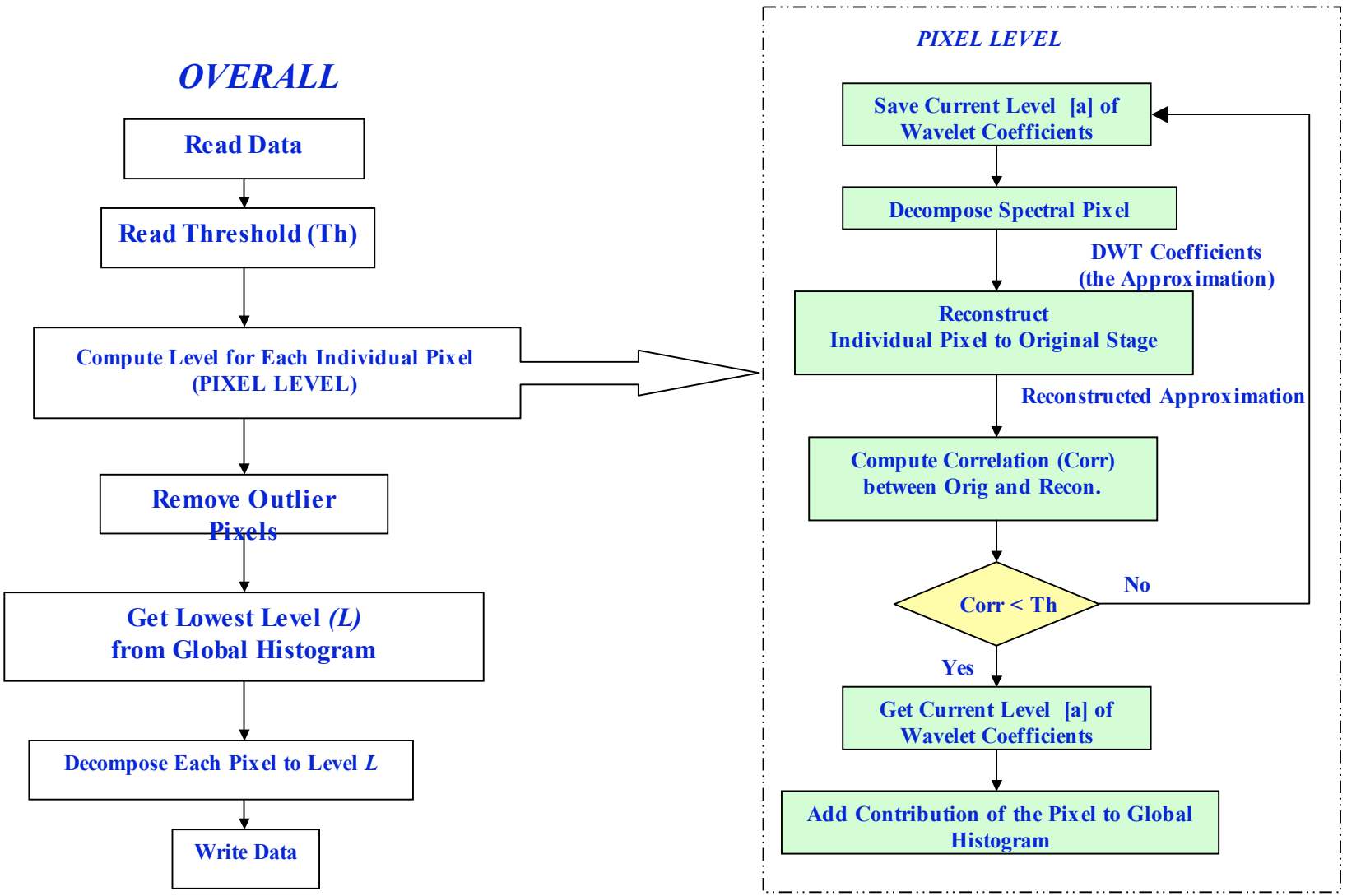


Discrete Wavelet Decomposition Transform

Algorithm used for Wavelet Based Dimension Reduction

- Multi-resolution wavelet decomposition of each pixel 1-D spectral signature.
- At each level of decomposition:
  - Reconstruction using only low-pass information
  - Similarity measure (e.g., correlation) between original signature and reconstructed signature for that decomposition level
  - Record that level in a histogram if it satisfies a quality of "good" reconstruction, defined by a percentage-threshold
- From the histogram, choose the optimum level of decomposition and build the corresponding dimension reduced image

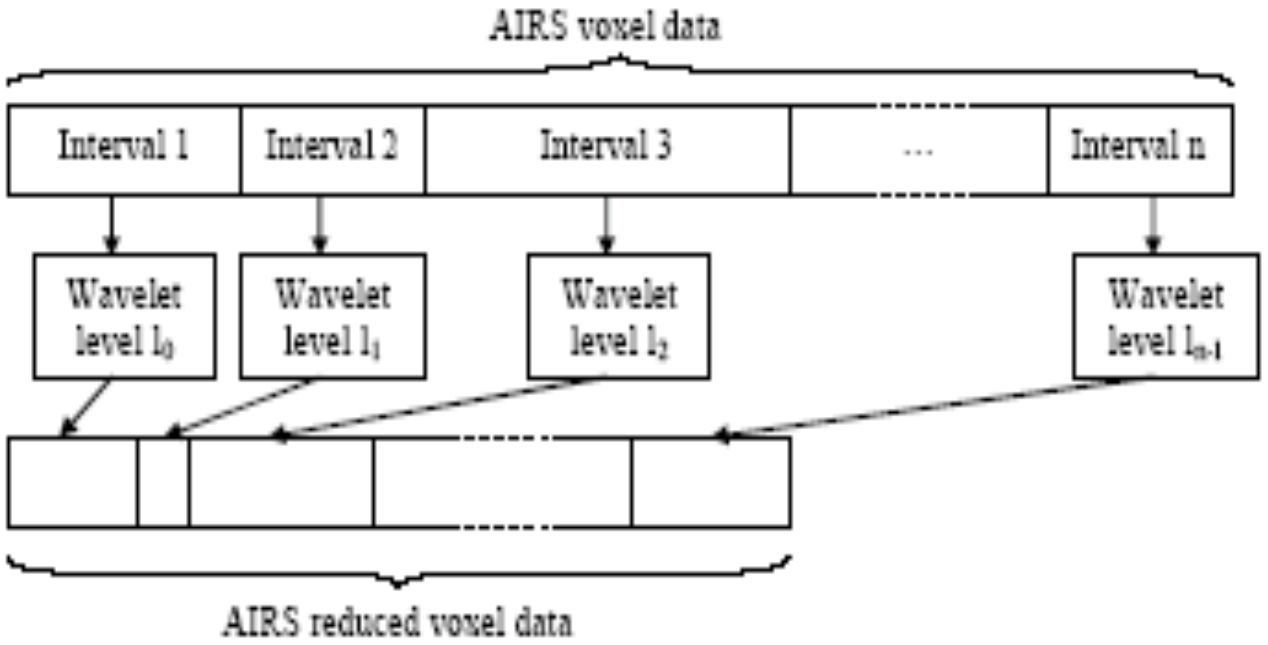
Algorithm Description



Experimental Setup

- Wavelet based dimension reduction of AIRS data involves the following steps:
  - Simulate the AIRS brightness temperature spectrum for a given profile using all the 2378 channels
  - Generate the AIRS brightness temperature spectrum using the new frequency, depending on the wavelet based reduction level
  - Since the frequencies are not same as the original dataset and the fast radioactive transfer scheme works on the predefined set, we use linear interpolation of the original spectrum to generate the brightness temperature

Wavelet Based Dimension Reduction over AIRS



AIRS Wavelet Dimension Reduction Processing

Experimental Data

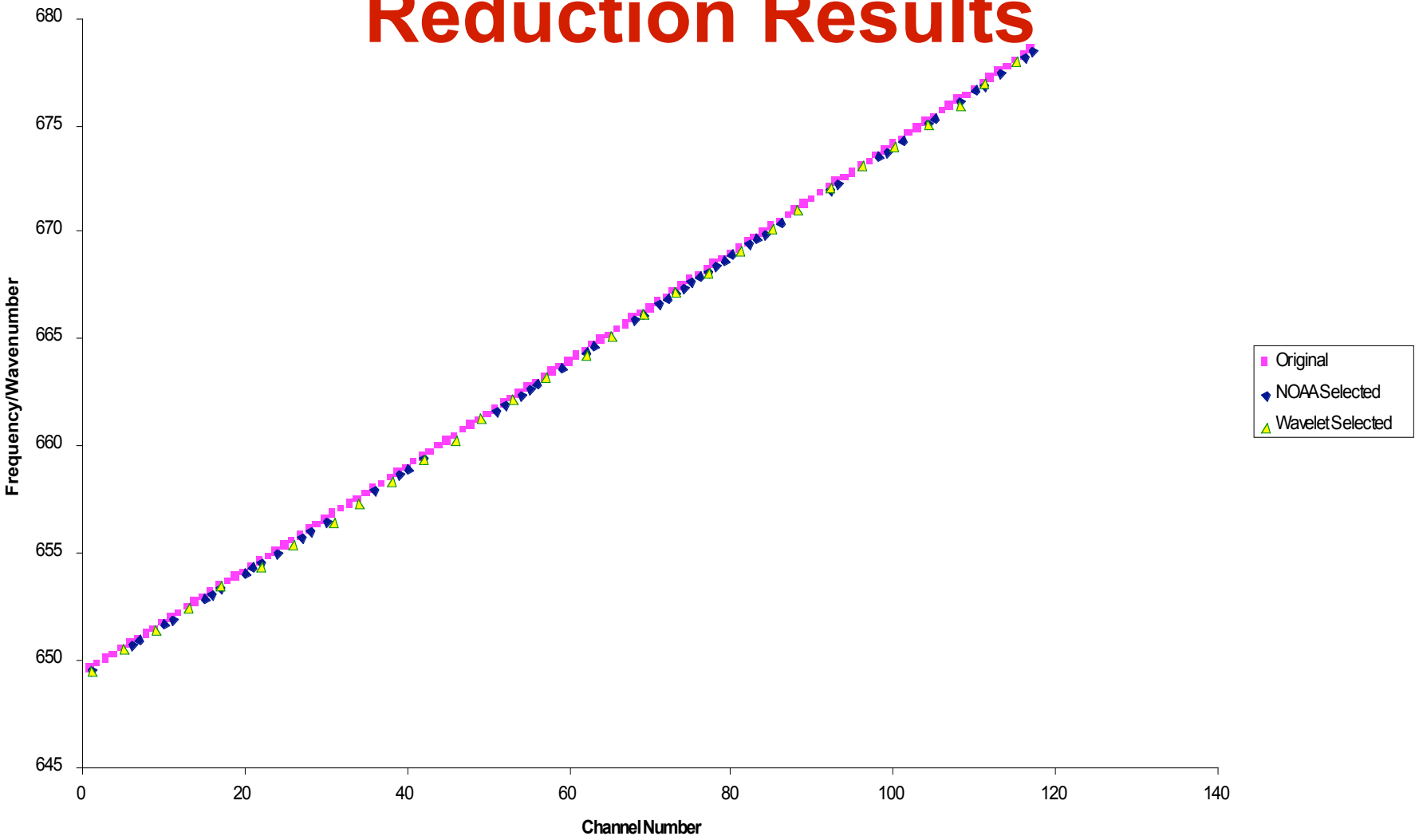
- Acquired on January 1, 2003
- Level 1B data contains AIRS infrared calibrated and geolocated radiances in milliWatts/m**2/cm**-1/steradian
- The data used is generated from AIRS level 1A digital numbers (DN), which includes 2378 infrared channels in the 3.74 to 15.4 μm region of the spectrum
- Contains 240 scenes, each of 6 minutes duration
- Each scene consists of 135 scan lines and each scan line has 90 cross-track footprints
- The 2378 infrared channels have been broken into three major intervals:
  - 3.74 - 4.61 micron, channel 1865 – 2378
  - 6.20 - 8.22 micron, channel 1263 – 1864
  - 8.80 - 15.4 micron, channel 1 – 1262

Experimental Data

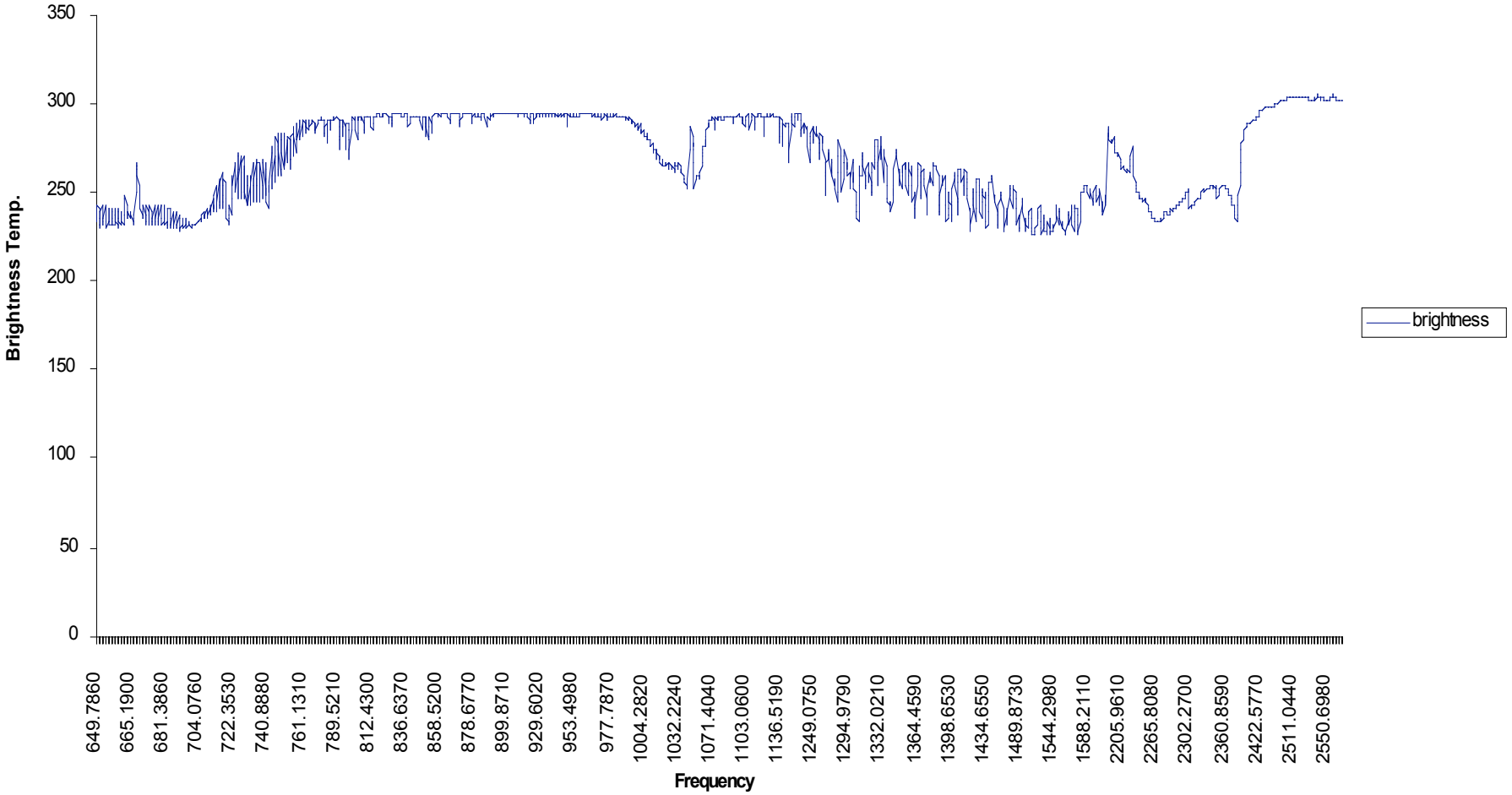
Interval #	Spectral Cuton (μm)	Spectral Cutoff (μm)	# bands	Starting Channel	Ending Channel
1	3.7364	3.9169	118	0	117
2	4.11	4.3291	130	118	247
3	3.9149	4.11	116	248	363
4	4.3271	4.6085	150	364	513
5	6.9356	7.4769	192	514	705
6	6.2003	6.4934	104	706	809
7	6.5504	6.85	106	810	915
8	7.4745	7.7921	94	916	1,009
9	7.8605	8.22	106	1,010	1,115
10	8.8073	9.4796	159	1,116	1,274
11	9.565	10.275	167	1,275	1,441
12	10.275	10.985	167	1,442	1,608
13	11.0704	11.7512	161	1,609	1,769
14	11.7431	12.685	167	1,770	1,936
15	12.7989	13.7457	167	1,937	2,103
16	13.7377	14.5533	144	2,104	2,247
17	14.6672	15.4	130	2,248	2,377

17 sub-Intervals for AIRS InfraRed Spectrometer Level 1B Data

Wavelet Based Dimension Reduction Results



Brightness Temperature Profile obtained from Reduced Channels



Concluding Remarks

- Successfully applied automatic wavelet-based dimension reduction algorithm over AIRS Data
- Results showed that additional information content about the data needs to be incorporated to do effective processing
- Processed the reduced data to obtain the brightness temperature profile
- Currently, we have used Linear interpolation to produce the selected frequency. Other interpolation methods can be used to obtain better results
- In the future, we will study the difference of the brightness temperature profile to the original data and compute an "error" covariance matrix

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